The United Nations World Water Assessment Programme

Insights

Global Trends in Water-Related Disasters: an insight for policymakers

Yoganath Adikari and Junichi Yoshitani

International Centre for Water Hazard and Risk Management (ICHARM)

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World Water Assessment Programme

The United Nations World Water Development Report 3
Water in a Changing World

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*Under the auspices of UNESCO at the Public Works Research Institute (PWRI), Tsukuba, Japan

Global Trends in Water-Related Disasters:

an insight for policymakers

Yoganath Adikari and Junichi Yoshitani

*International Centre for Water Hazard and Risk Management (ICHARM)**

Executive summary

Global trends in water-related disasters: an insight for policymakers is a unique report designed to support future national disaster policy programmes. Trends in natural disasters show they are continuously increasing in most regions of the world. Among all observed natural and anthropogenic adversities, water-related disasters are undoubtedly the most recurrent and pose major impediments to the achievement of human security and sustainable socio-economic development, as recently witnessed with the disasters caused by the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, Cyclone Sidr in 2007, Cyclone Nargis in 2008, and many others. During the period 2000 to 2006, a total of 2,163 water-related disasters were reported globally in the Emergency Disasters Database (EM-DAT), killing more than 290,000 people, affecting more than 1.5 billion, and inflicting more than US$422 billion of damage. This report is designed to help develop understanding of global requirements and challenges in fighting against water-related disasters, to evaluate the effectiveness of adopted policies in water-hazard mitigation, and to plan future development with better understanding of disaster vulnerability.

The report is divided into four parts. Section one is an introduction. The second section presents an overview of natural and water-related disasters from 1900 to 2006. The third section analyses recent trends in global and regional water-related disasters since 1980. The fourth, concluding section presents some recommendations based on the findings of the report.

The report analyses data compiled for the International Centre for Water Hazard and Risk Management (ICHARM) in the Public Works Research Institute (PWRI) Technical Notes Nos. 4088 and 3985. Data from the Emergency Events Database (EM-DAT) of the Centre for Research on Epidemiology of Disasters (CRED), widely regarded as being the most reliable existing database, are used throughout unless stated otherwise.

The frequency of natural disasters between 1990 and 2006, particularly water-related disasters, has increased markedly – as has the estimated economic damage they cause. Extreme events have also become more frequent. Between 1900 and March 2007, 16,301 disaster events were recorded throughout the world – 6.27 billion people were affected; fatalities were more than 37.58 million and the estimated economic damage was more than US$1,790 billion. Disasters triggered

by hydrometeorological events outnumbered all other disasters combined. Floods, droughts and windstorms have been the most frequently occurring disaster events since 1900. They account for 88.5% of the thousand most disastrous events. More than 83% of flood-related disasters occurred in Asia. The number of fatalities per decade has shown a continuous decrease from nearly two million people in the 1960s to half a million in the 1990s (United Nations World Water Assessment Programme [UN-WWAP], 2006).

As pointed out earlier, the results of a detailed analysis of global and regional water-related disasters between 1980 and 2006 show that global water-related fatalities decreased while the number of people affected and the estimated economic damages increased. In terms of fatalities and the number of people affected, Asia is the region most vulnerable to water-related disasters, accounting for more than 45% of fatalities and more than 90% of the people affected by disasters. However, the recorded number of fatalities was highest in Africa, accounting for more than 46% of the world total. These facts simply mean that more must be done to mitigate natural disasters – particularly future water-related disasters, given the catalysing effect of climate change.

Last but not least, disaster trend analysis is crucial for understanding the patterns of past disasters, and is helpful for examining and perceiving future disaster risk and vulnerability. This report also shows that water-related disasters are clearly increasing every year – causing enormous damage to life and property, some of which could have been protected through appropriate development choices – and that future development is just as much at risk. However, the number of fatalities has decreased drastically, due to the efforts of those involved in the process of disaster management. The most remarkable thing to note is that in Bangladesh the numbers of fatalities due to similar magnitude cyclones decreased from more than 300,000 in 1970 to just over 5,000 people in 2007. This clearly shows that disaster management efforts are not made in vain, and obviously would benefit from more attention. Therefore it is recommended that policy makers and managers study water-related disaster trends and factor disaster risk management into development policy at the national level. National and international disaster databases are vital for sound planning for future sustainable development.

As a global good and a global risk, water is in need of global governance for the mitigation of adverse impacts.

Abbreviations

ADRC	Asian Disaster Reduction Center
CRED	Centre for Research on Epidemiology of Disasters
EM-DAT	Emergency Disasters Database
GLIDE	GLobal IDEntifier number
ICHARM	International Centre for Water Hazard and Risk Management under the auspices of UNESCO
IDNDR	International Decade for Natural Disaster Reduction
LA RED	Network for Social Studies on Disaster Prevention in Latin America
MLIT	Ministry of Land, Infrastructure, Transport and Tourism, Government of Japan
OCHA	Office for Coordination of Humanitarian Affairs
OFDA	Office of Foreign Disaster Assistance
UN-DHA	United Nations Department of Humanitarian Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UN-ISDR	United Nations International Strategy for Disaster Reduction
UNU	United Nations University
UNU-EHS	United Nations University Institute for Environment and Human Security
UN-WWAP	United Nations World Water Assessment Programme
USAID/OFDA	The US Agency for International Development/ Office of U.S. Foreign Disaster Assistance
NOAA	National Oceanic and Atmospheric Administration
FEMA	Federal Emergency Management Agency, United States of America
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization
WWDR 2	World Water Development Report 2
WWDR 3	World Water Development Report 3
Units	All the monetary units and counting follow the American system

1. Introduction

Background

Trends in natural disasters show they are continually increasing in most regions of the world. Among all observed natural and anthropogenic adversities, water-related disasters are undoubtedly the most recurrent, and pose major impediments to achieving human security and sustainable socio-economic development, as recently witnessed with disasters such as the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, Cyclone Sidr in 2007, Cyclone Nargis in 2008 and many others. During the period 2000 to 2006, 2,163 water-related disasters were reported globally in the EM-DAT database, killing more than 290,000 people, afflicting more than 1.5 billion people and inflicting more than US$422 billion in damages.

The factors that have led to increased water-related disasters are thought to include natural pressures, such as climate variability; management pressures, such as the lack of appropriate organizational systems and inappropriate land management; and social pressures, such as an escalation of population and settlements in high-risk areas (particularly for poor people). The United Nations University Institute for Environment and Human Security (UNU-EHS) warns that unless preventative efforts are stepped up, the number of people vulnerable to flood disasters worldwide is expected to mushroom to two billion by 2050 as a result of climate change, deforestation, rising sea levels and population growth in flood-prone lands (Bogardi, 2004).

These escalating figures confirm the existence of an overall deficiency in up-to-date management strategies to reduce the risks of water-related disasters. The World Conference on Disaster Reduction, held in Kobe, in Japan's Hyogo Prefecture, from 18 to 22 January, 2005, resolved that 'disasters have a tremendous detrimental impact on efforts at all levels to eradicate global poverty; the impact of disasters remains a significant challenge to sustainable development'. The Hyogo Declaration adds that 'it is critically important that the Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters be translated into concrete actions at all levels and that achievements are followed up through the International Strategy for Disaster Reduction, in order to reduce disaster risks and vulnerabilities.' The international community 'also recognizes the need to develop indicators to track progress on disaster risk reduction activities as appropriate to particular circumstances and capacities as part of the effort to realize the expected outcome and strategic goals set in the Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters' (World Conference on Disaster Reduction [WCDR], 2005, extracts from the Hyogo Declaration).

Flood in Laos. Photograph: Fukami, K.

The objectives of this report

This report highlights a broad spectrum of trends in water-related disasters, broken down specifically by time scale, region, damage type and disaster type, in order to provide an in-depth understanding of water-related disaster trends in the past as a key database to use in policy and strategy formulation. Its specific objectives are:

- to present an overall picture of water-related disasters in comparison with non-water-related natural disasters,
- to present the detailed trends of water-related disaster in the past by time scale, region, damage type (the number of events, amount of human loss, number of people affected, and economic damages), and disaster type;
- to develop an understanding of the relationship between these trends to use as base information for inferring the effectiveness of past disaster risk-reduction efforts and to plan required actions;
- to highlight the importance of disaster databases for sounder policy-making and planning;
- to lead the development and application of indicators that assist in identifying underlying risks and to evaluate the effectiveness of adapted policies.

Note that the data and figures analysed in this report are taken from PWRI Technical Notes Nos. 4088 (PWRI, 2008) and 3985 (PWRI, 2005), which provide more detailed analysis.

Disaster record sources for trend analysis

For this report we used the emergency database, EM-DAT, a global database maintained by the World Health Organization (WHO) Centre for Research on the Epidemiology of Disasters (CRED)

Floods and devastation caused by an earthquake and consequent landslide in 2004 in Japan. Photograph: Adikari, Y.

at the University of Louvain, Belgium since 1988. Since January 1999, the Office of Foreign Disaster Assistance (OFDA) of the United States Agency for International Development (USAID) has also supported CRED in improving the database. OFDA and CRED have established and maintained a single database to improve capacities to cope with disasters and to prevent them from happening. The main objective of the database is to serve the purposes of humanitarian action at national and international levels. It is an initiative aimed at rationalizing decision-making for disaster preparedness as well as providing a strong base for vulnerability assessment and priority-setting. EM-DAT regularly validates and updates disaster data from various national and international organizations that specialize in disaster information analysis and dissemination.

Trend analysis is *sine qua non* for the development of vulnerability assessment methodologies, for serving the purposes of formulating policy scenarios, and for rationalizing decision-making for proactive disaster preparedness. There are a number of national and international efforts to create disaster databases towards achieving strategic goals in disaster mitigation and developing institutional and international standards for the achievement of the global objectives of sustainable development.

EM-DAT is the selected data source for this report because it is the only database that records all the components of disasters. It is widely used by international agencies and thought to be a very reliable data source on disasters throughout the world, although other databases such as those of the Dartmouth Flood Observatory, MunichRe, SwissRe, LARED and others exist in more specific contexts. The Report focuses on the general trends of water-related disasters between 1900 and 2006, and on an in-depth analysis of disasters that took place between 1980 and 2006 because the data quality improved in the 1980s. Therefore an in-depth analysis of water-related disasters since 1980 is meaningful for policy development.

Disaster record classification

The classification of an event as a disaster varies from database to database, due to large differences in scope, focus and the objectives of organizations engaged in collecting and distributing disaster information. EM-DAT defines and gathers records on a disaster if it falls into at least one of the following categories:

- there have been ten or more fatalities,
- one hundred or more people have been affected,
- a state of emergency has been declared, or
- international assistance has been called for.

Disaster events in the database are classified based on disaster group (e.g., natural disaster), disaster type

(e.g., flood) and disaster sub-type (e.g., flash flood). In this report, if a term such as 'flood' is used, the data for all its sub-types as categorized by EM-DAT are added together and analysed. Different types of natural disasters have the following sub-types:

Floods: Coastal and lake flood, plain flood, valley flood, and flash flood

Windstorms: Typhoon, hurricane, cyclone, tornado, tropical storm, winter storm, and storm (non-water-related disasters may be included in this disaster type. However, this report considers all windstorm disasters as water-related disasters.)

Waves and surges: Tidal wave and tsunami

Slides: Landslide, avalanche, mudflow and rockfall

Droughts: no sub-type

Epidemics: no sub-type (In this report epidemics are divided into two categories, water-borne and non-water-borne, in order for water-borne epidemics to be categorized as water-related disasters. This categorization criterion is adapted from the WHO definition of water-borne epidemics).

EM-DAT definitions for the terms such as region, disaster-category, and disaster-type are used in this report. Some of these definitions are vague, especially those of disaster types. For instance, a flood can be triggered simultaneously by heavy rain caused by a rain front and a typhoon, but is difficult to pinpoint which caused the flood.

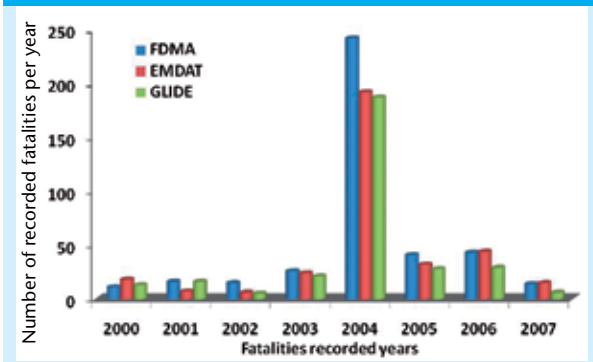
Data reliability and availability:

The main detrimental factors concerning disaster data reliability are as follows:

- The damage itself may be unknown on the global scale. There are places where population size is not known, so if a disaster occurs, the fatalities or number of people affected cannot be calculated.
- Sometimes the event is known but is not reported.
- There may be political bias: some countries like to exaggerate, and some like to hide disaster damage for their own political reasons.
- The events are recorded in certain databases but not in others, also, the recorded data may differ because of differences in entry criteria and vague definitions.
- Reporting systems may be faulty, disaster assessment methods biased, reporting mechanisms politically influenced, or the identification and quantification of social and economic damage unreliable.
- Data-management practices may be poor.

Database users must take the utmost precaution to ensure data source reliability and avoid political bias. A number of commentators have reported that disaster entry criteria are a major factor that

Figure 1.1 **Water-related disaster fatalities in Japan.**



Compiled from three different databases for comparison. (Fire and Disaster Management Agency (FDAM), Japan, is considered to be the most accurate database in Japan.)

leads to differences between disaster databases. The accountability of fatalities and the reported number of people affected are also influenced by the social and political conditions of the country where the disaster has occurred (Arakida and Murata, 2003; Guha-Sapir and Below, 2002; Guha-Sapir et al, 2004; Hoyois and Guha-Sapir, 2004; Hoyois et al., 2007; Wisner et al., 2004).

Comparisons of water-related disaster data in three different disaster databases – EM-DAT; the database of the Japanese Fire and Disaster Management Agency (FDMA, 2008, which provides the official and most reliable human loss statistics in Japan); and the GLobal unique disaster IDEntifier number (GLIDE) produced by the Asian Disaster Reduction Center (ADRC) – indicate that between 2000 and 2007, these three databases differed in all annual totals of disaster fatalities (Figure 1.1), which illustrates some of the above-mentioned detrimental factors. This difference among databases can create confusion and misunderstanding.

Many definitions are ambiguous – and the most ambiguous of all probably concerns defining the number of people affected. In terms of data reliability, the number of events is the most reliable, followed by the estimated economic damage, the number of fatalities, and then the number of people affected. A PWRI study showed two million fatalities reported during the 1959 flood in the Republic of China, but there was no record for the number of people affected (PWRI, 2008). The figures reported to the EM-DAT of the number of people affected is not reliable.

The availability of reliable datasets for policy-making and planning is one of the most critical factors for understanding the real state of a disaster. Many countries in the world do not have efficient mechanisms for accurate disaster damage records, and even where they do have such mechanisms, they are not always open to others. Therefore, disaster databases for policymaking and planning must become more reliable than are existing databases.

Flood in Laos. Photograph: Fukami, K.

2. Natural and Water-Related Disasters from 1900 to 2006

Natural disaster trends

This section deals with the overall picture of water-related disasters in comparison with non-water-related disasters between 1900 and 2006 (although according to CRED the data reliability is poor, as was explained in Section 1).

The number of disaster events, which is thought to be the most reliable single record in the dataset, shows an increasing trend especially from the 1960s on (Figure 2.1). The number of events almost doubled at the turn of this century. This may coincide with the evolution of modern communications, which made it possible to collect reports from any part of the world much more easily. Between 2004 and 2006, 1,047 water-related disasters, with more than 272,000 fatalities and 429 million victims reported.

However, the number of natural disaster fatalities has dropped significantly in recent years (Figure 2.2). In spite of population increases around the world, the steady decline of fatalities might be attributed to continuous efforts made by various governments, national and international organizations, and other agencies involved in disaster management. But the escalation of property damage, especially in the 1980s and 1990s, indicates the extent of the loss of development gains. The economic loss also highlights the concentration of property in vulnerable disaster-prone zones. Recent fatalities, the number of people affected and economic damage incurred through water-related disasters are dealt with in detail in the following section.

The recorded number of disaster events around the world between 1900 and 2007 was 16,301, and the number of people affected was 6.27 billion, with more than 37.58 million fatalities. The estimated total damage to 2006 was more than US$1,325 billion (Table 2.1), but 2008 data show that this figure has now exceeded US$1,790 billion. Disasters triggered by hydrometeorological events are the most frequent disaster type, outnumbering all other natural disasters combined, and have the widest impacts on people.

Figure 2.1 **Natural disaster events recorded globally between 1900 and 2006**

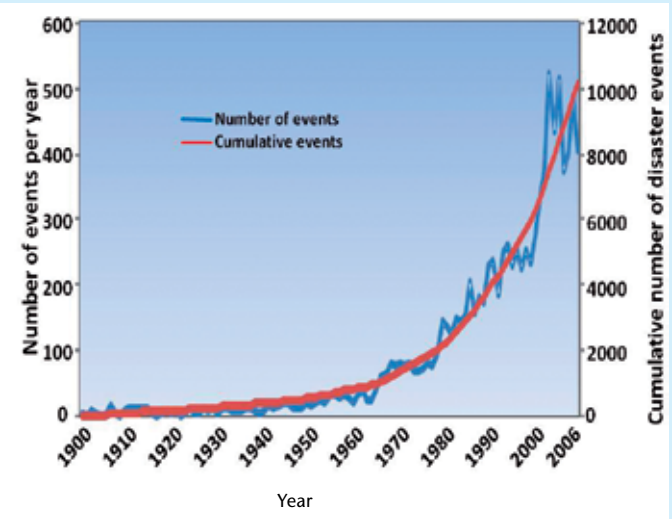
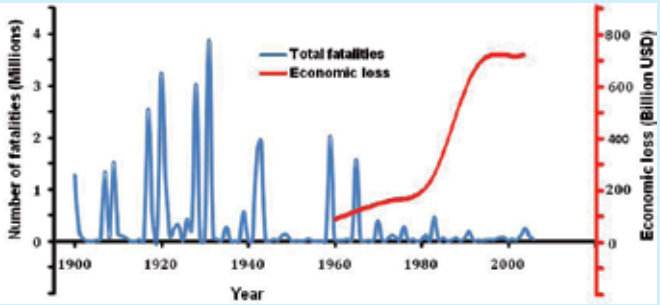


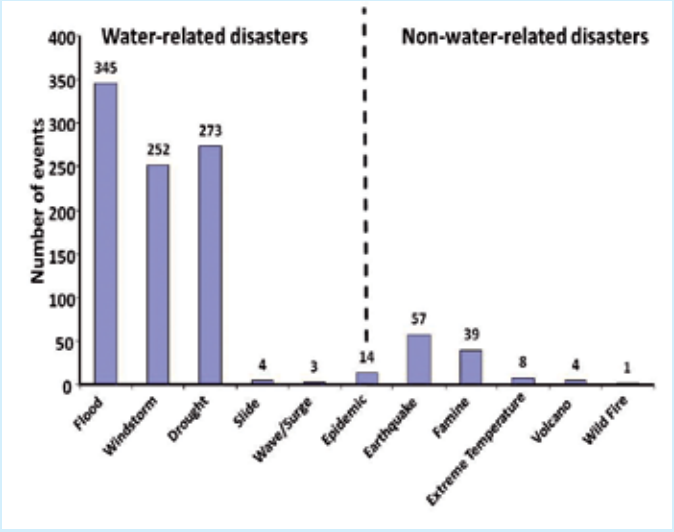
Figure 2.2 **Natural disaster fatalities worldwide, with decadal increment of economic losses from natural disasters**



The number of earthquakes was only one-third that of the number of floods between 1900 and 2006, but the percentage of the total estimated economic disaster-related damage that was caused by earthquakes was 24%, whereas that of floods was only slightly higher, at 25.9% (Table 2.1), making earthquakes the most physically damaging natural disaster. Yet

Drought in Jordan. Photograph: Noro, T.

Figure 2.3 **One thousand most disastrous natural disaster events from 1900 to 2006**



a closer look at the impact summary indicates that there is a complex relationship between the number of fatalities and victims by each type of water-related disaster. Between 1900 and 2006, floods accounted for 29.8% of the total number of natural disasters – claiming more than 18.5% of the total casualties and more than 48% of the total number of people affected. Flood and windstorm events taken together from 1900 to 2006 account for 56.7% of the total number of disasters and more than 21.7% of fatalities – or more than 60.3% of all natural disaster victims. Of the economic damage caused by natural disasters, 71.9% can be attributed to water-related disasters, of which 25.9% is attributed to floods and 40.5% to windstorms.

Furthermore, analysis of the one thousand most fatal natural disasters between 1900 and 2006 shows that about 90% are water-related disasters (Figure 2.3). This simply means that water-related disasters are more frequent and more hazardous. Among non-water-related disasters, earthquakes, famines and extreme temperatures are most frequent.

Table 2.1 **The frequency of recorded natural disaster occurrences globally between 1900 and 2006**

	1900-2006	Number of Disasters	(%)	Number killed	(%)	Total affected	(%)	Real Damage	(%)
Water-related Disasters	Flood	3,050	29.8	6,899,095	18.5	3,027,693,701	48.3	342,968,287	25.9
	Windstorm	2,758	26.9	10,008,806	3.2	752,843,507	12.0	536,432,227	40.5
	Drought	836	8.2	1,208,806	26.8	2,239,624,826	35.7	61,262,901	4.6
	Slides	508	5.0	55,980	0.2	10,206,768	0.2	3,487,457	0.3
	Wave/Surge	52	0.5	295,813	0.8	2,596,663	0.0	7,850,747	0.6
Non Water-related Disasters	Epidemic	1,035	10.1	9,528,995	25.6	40,156,618	0.6	4,737	0.0
	Wild Fire	312	3.0	2,710	0.0	4,019,267	0.1	29,574,293	2.2
	Extreme Temperature	322	3.1	69,138	0.2	11,466,747	0.2	21,843,847	1.6
	Volcano	193	1.9	95,917	0.3	4,907,517	0.1	3,842,646	0.3
	Insect Infection	83	0.8	0	0.0	2,200	0.0	230,125	0.0
	Famine	76	0.7	7,158,229	19.2	70,996,301	1.1	93,449	0.0
	Earthquake	1,025	10.0	1,963,172	5.3	104,038,367	1.7	317,580,870	24.0
	Total	**10,250**	**100.0**	**37,286,332**	**100.0**	**6,268,551,482**	**100.0**	**1,325,171,586**	**100.0**

Figure 3.1 **Water-related disaster events recorded globally, 1980 to 2006**

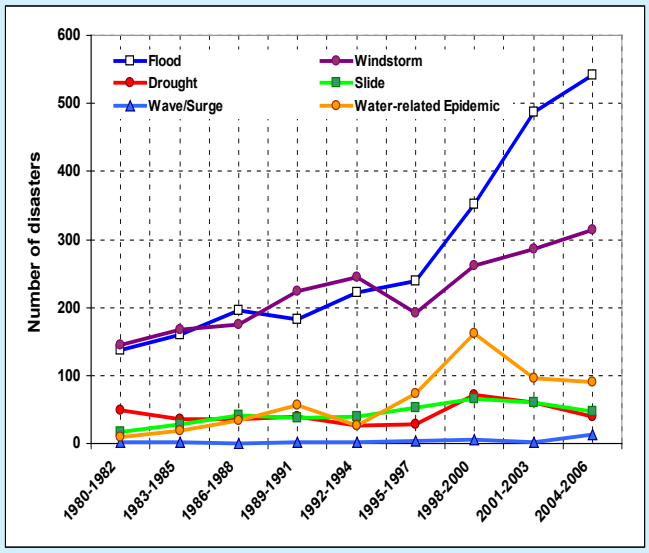
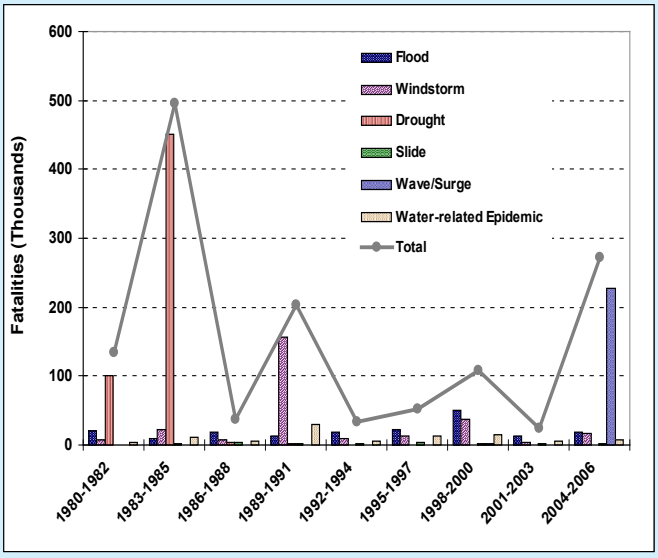


Figure 3.2 **Fatalities caused by water-related disasters globally, 1980 to 2006**



3. Global and regional water-related disasters from 1980 to 2006

Global trends of water-related disasters

This section presents the detailed trends of water-related disasters between 1980 and 2006 according to region, damage type and disaster type. According to CRED, the data reliability for the period from 1980 to 2006 is higher than that for the period before 1980, as was explained in Section 1. This section is divided into five parts. The first deals with global trends in general, the second with regional trends of disaster types, the third with regional fatalities, the fourth with the numbers of people affected, in terms of region, and the fifth section examines various scenarios.

The number of events

In general, all water-related disasters events increased between 1980 and the end of the twentieth century (Figure 3.1). Floods and windstorm events increased drastically from 1997 to 2006, but other types of disaster did not increase significantly in this period. Floods doubled during the period 1997 to 2006 and windstorms increased more than 1.5 times. Drought was severe at the beginning of the 1980s and gained momentum again during the late 1990s and afterwards. The numbers of landslides and water-borne epidemics were at their highest during the period 1998–2000 and then decreased. Waves and surges increased between 1980 and 2006.

Fatalities

In general, water-related disaster fatalities followed a decreasing trend (Figure 3.2), but the fatalities record has occasional peaks. Droughts crested in the period 1983–1985, windstorms between 1989 and 1991, and waves and surges between 2004 and 2006. These peaks are attributed to the drought in Ethiopia in 1984, which resulted in 300,000 fatalities; the windstorm in Bangladesh in 1991, where 138,866 people died, and the 2004 Indian Ocean tsunami, which caused 227,237 fatalities.

This shift in water-related disasters is alarming – even places that have never experienced these disasters before are experiencing them now. Promoting better awareness and preparedness for this sort of shift, and improving people's ability to cope with unusual events, are becoming increasingly challenging.

The number of people affected

The number of people affected by water-related disasters showed an increasing trend during the period 1980 to 2006 in general, with the highest peak between 2001 and 2003 (Figure 3.3). The number of people affected by a single natural disaster usually varies from several hundred thousand to several million, depending on the type and location of the disaster. For example, a drought in India in 1987 affected 300 million people. The number of people affected by disasters increased in the late 1980s and then decreased until another sharp increase in the period from the late 1990 to 2003 – caused by floods in China, which affected more than 150 million, and droughts in India in 2002, which affected 300 million people.

Economic loss

In general, the estimated water-related economic losses globally show an increasing trend (Figure 3.4). The trend had a trough during the period 2001 to 2003, and then increased sharply until 2006. The increase was due to the huge economic damage caused by Hurricane Katrina in the United States in 2005. The estimated damage caused by floods increased until the turn of the twenty-first century and then decreased. Among water-related disasters,

Figure 3.3 **Recorded number of people affected by water-related disasters globally, 1980 to 2006**

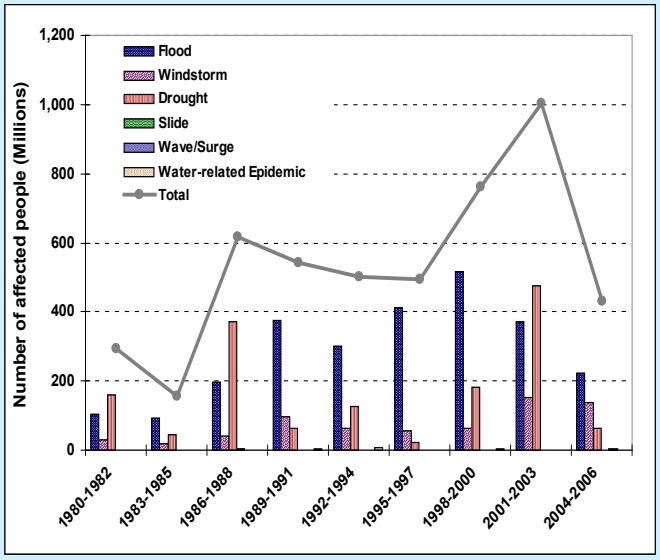
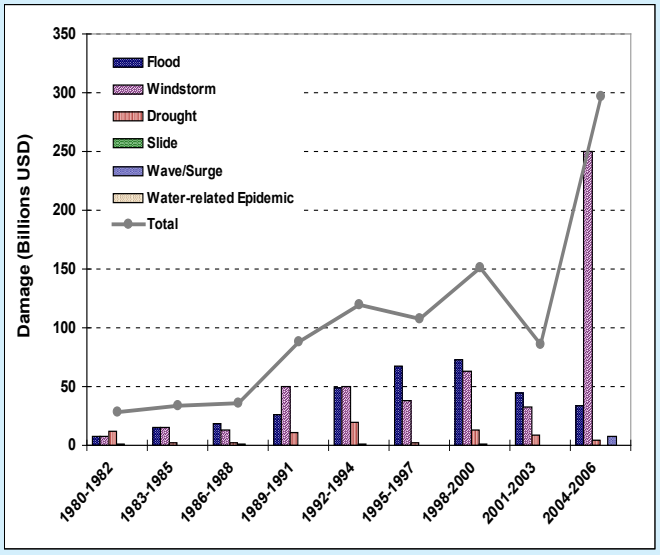


Figure 3.4 **Estimated economic damage caused by water-related disasters globally, 1980 to 2006**



windstorms, floods and droughts are the main contributors to economic losses – in descending order – and the rest of the water-related disasters are insignificant but underestimated.

The estimates of economic losses caused by water-related disasters in different parts of the world may not be entirely reliable, because the values obtained from different countries are derived under different definitions and using different estimation methods, monetary units and purchasing power.

Furthermore, some countries do not carry out surveys or keep proper records, while others may keep their records confidential. Reported figures may not be accurate and are sometimes even exaggerated to attract media attention.

Regional trends in the number of water-related disasters

In general, the number of water-related disasters increased between 1980 and 2006 in every region (Figure 3.5). The numbers of water-related disasters recorded was highest in Asia and increased linearly to more than double, from 160 events during the period 1980 to 1982 to 427 events between 2004 and 2006. Water-related disasters also increased more than four-fold in Africa in the 1990s. The rate of this increase was more drastic than the rate of increase in Asia, and Africa overtook the Americas to take second place in terms of the number of water-related disasters. In Europe, water-related disasters also increased from the early 1980s to 2006.

Data on the regional distribution of water-related disasters between 1980 and 2006 indicates that Asia was the region most frequently hit, followed by the Americas, Africa, Europe and Oceania, in that order.

The major disasters in Asia were floods, windstorms and slides; in Africa, they were floods, epidemics and droughts; in the Americas, they were floods, windstorms and slides; in Oceania, they were windstorms and floods; and in Europe, floods (PWRI, 2008).

Floods

In general, the number of floods increased between 1980 and 2006 in every world region (Figure 3.6). The number of floods was recorded as being highest in Asia and more than trebled during the period. Floods increased more than four-fold in Africa in the 1990s, which overtook the Americas to take the

Figure 3.5 **Recorded water-related disasters by region, 1980 to 2006**

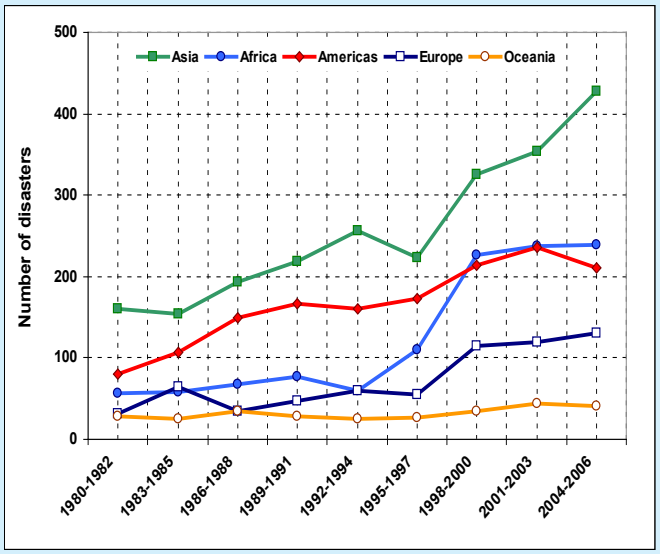


Figure 3.6 **Recorded numbers of floods by region, 1980 to 2006**

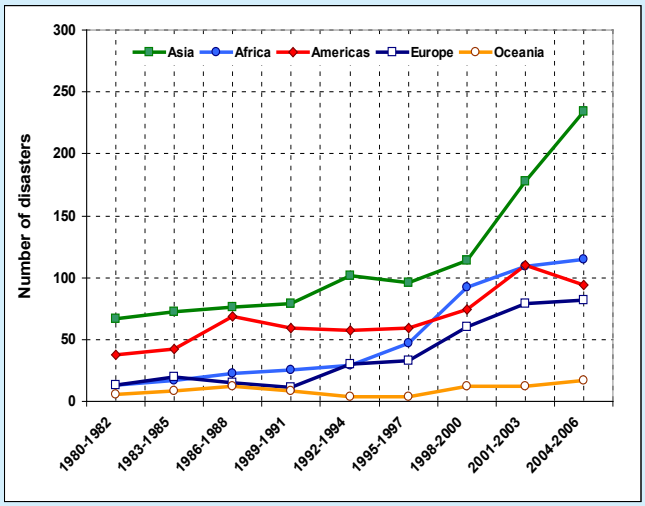


Figure 3.7 **Recorded numbers of windstorms by region, 1980 to 2006**

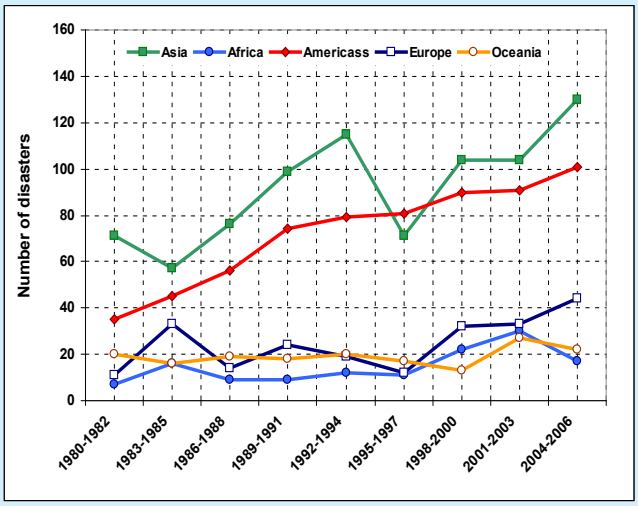


Figure 3.8 **Recorded numbers of slides by region, 1980 to 2006**

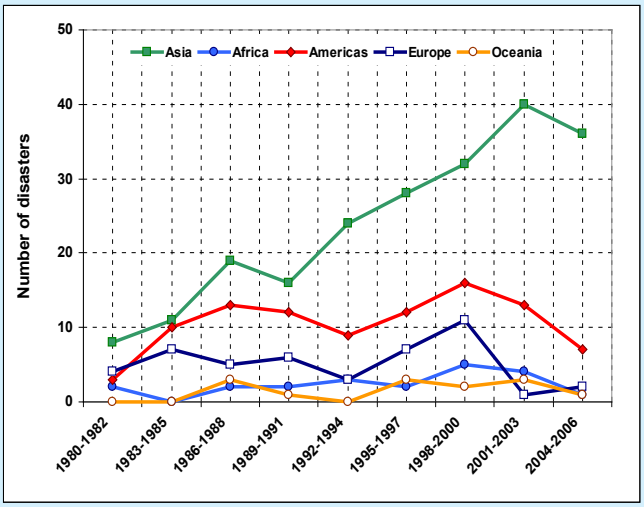


Figure 3.9 **Recorded numbers of waves and surges by region, 1980 to 2006**

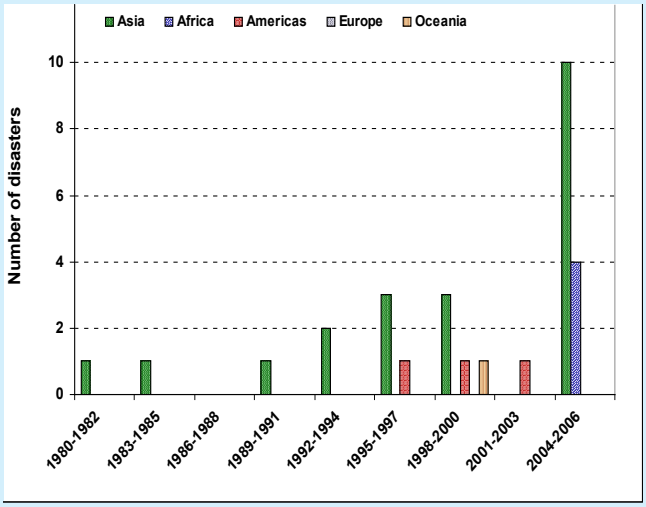


Figure 3.10 **Recorded numbers of droughts by region, 1980 to 2006**

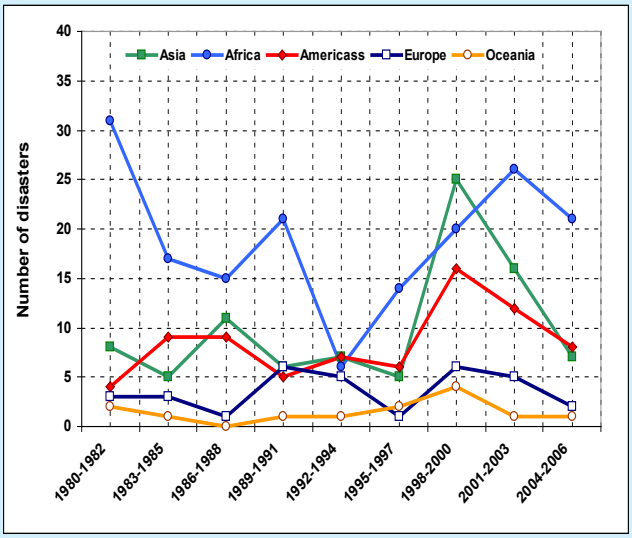


Figure 3.11 **Recorded numbers of water-borne epidemics by region, 1980 to 2006**

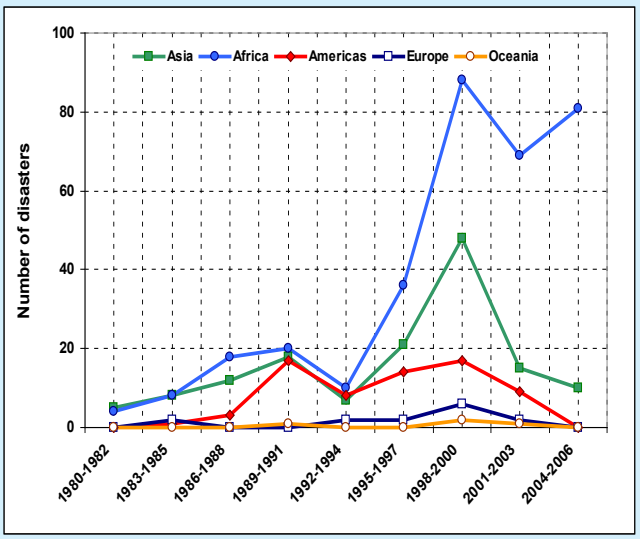


Table 3.1 **The reported number of fatalities, their totals and percentage ratios and regional totals for each type of water-related disaster between 1986 and 2006**

Continent	Flood (%)	Wind storm (%)	Slide (%)	Wave and surge (%)	Drought (%)	Epidemics (%)	Continent total (%)
Asia	117325 (64.4)	231382 (84.6)	13371(64.0)	227457(98.9)	4962 (0.9)	27243 (27.7)	**621740 (45.6)**
Africa	14673 (8.1)	3175 (1.2)	437(2.1)	312(0.1)	553118 (99.1)	56922 (58.0)	**628637 (46.1)**
America	47782 (26.2)	36276 (13.3)	5288(25.3)	10 (0.0)	73 (0.0)	13776 (14.0)	**103205 (7.6)**
Europe	2120 (1.2)	1917 (0.7)	1362(6.5)	0 (0.0)	2 (0.0)	206 (0.2)	**5607 (0.4)**
Oceania	218 (0.1)	656 (0.4)	428(2.0)	2182 (0.9)	60 (0.0)	28 (0.0)	**3572 (0.3)**
Total fatalities per disaster type	**182118 (13.4)**	**273406 (20.1)**	**20886 (1.5)**	**229961 (16.9)**	**558215 (41.0)**	**98175 (7.2)**	**1362761 (100)**

second-worst rank. In Europe floods increased from the early 1980s to 2006.

Windstorms

Windstorms increased between 1980 and 2006 in every region (Figure 3.7), except for a trough during the period from 1995 to 1997 in Asia. It is worth noting that windstorms increased steadily in the Americas throughout the period from 1980 to 2006. Asia is the most windstorm-prone region, closely followed by the Americas. The other regions are also hit by windstorms, but less frequently.

Slides

Slides (landslides and avalanches, see Glossary) did not show any distinct trends in any region except in Asia, where they increased more than four-fold, with the highest numbers recorded between 1980 and 2006 – although there was a decline between 2003 and 2006 (Figure 3.8). The Americas are second in terms of the number of slides, but have shown nothing like the increases seen in Asia and there was no significant change in the number of slides during this period. Numerous gigantic slides were recorded between 1980 and 2006 in India and China, followed by Bangladesh, the Philippines and Iran.

Waves and Surges (including tsunami)

Because waves and surges occur only occasionally, it is impossible to analyse the trends between 1980 and 2006 (Figure 3.9). From 1980 until the mid-1990s, no waves and surges were recorded in any region except in Asia. But since the mid 1990s, waves and surges have been recorded in the Americas, and since 2000, waves and surges have begun to occur in other regions including Africa and Oceania.

Droughts

The numbers of droughts did not show any clear pattern from 1980 to 2006 (Figure 3.10) though droughts are prominent in Africa. In the African region, droughts decreased in the period from 1992 to 1994, then increased again. Asia and the Americas suffered the highest number of droughts between 1998 and 2000. It is interesting to note that droughts in all regions except Africa peaked between 1998 and 2000 and then declined.

It has been reported in recent years that droughts have caused huge damage in regions other than Africa, through crop failures in Australia, the Mediterranean region, some parts of Europe such as Spain and Portugal, and parts of Asia such as India and China.

Epidemics

Water-borne epidemic diseases show an increasing trend between 1980 and 2006; especially from the mid 1990s (Figure 3.11), which is alarming. A drastic increase in epidemics coincides with the increasing number of floods and windstorms, which supports a conclusion that water-borne epidemics are a direct aftermath of these disastrous events. The geographical distribution indicates that Africa is severely affected by epidemics (PWRI, 2008), suffering a total of 334 water-borne epidemics between 1980 and 2006, whereas Asia encountered less than half that number (145 events). Globally, the number of epidemics was at its highest in the period from 1998 to 2000, which is thought to be influenced by the African and Asian regional peaks. It is worth noting that Asia and Africa had similar patterns in terms of the number of water-borne epidemics until 2000, after which they declined in Asia but became more vigorous in Africa.

Regional trends in the number of fatalities caused by water-related disasters

Floods

There was no particular regional trend in the number of fatalities caused by floods between 1980 and 2006 except in Africa, where the numbers increased steadily (Figure 3.12). Flood fatalities in Asia ranked worst, followed by the Americas, Africa, Europe and Oceania in that order. There are fluctuations, such as the crest in Asia from 1989 to 1991, which was in six-digit figures, and the crest in the Americas between 1998 and 2000, caused by a flood in Venezuela that killed 30,000 people. In the late 1980s the number increased from three- to four-digit figures in Africa. Between 1980 and 2006, flood disasters throughout the world claimed more than 182,000 lives, and Asia alone accounted for more than 64% of the global total, followed by the Americas with more than 26% (Table 3.1).

Figure 3.12 **Trends in flood fatalities by region, 1980 to 2006**

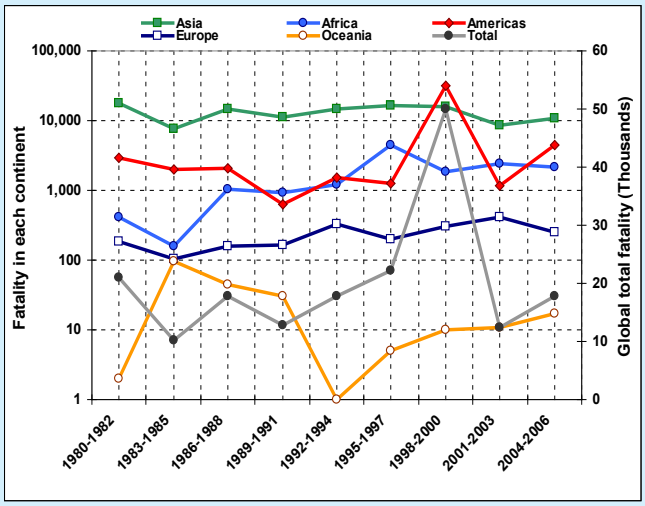


Figure 3.13 **Trends in windstorm fatalities by region, 1980 to 2006**

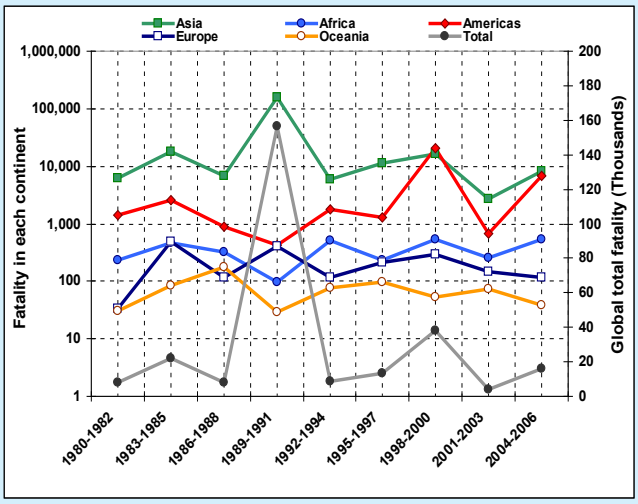


Figure 3.14 **Trends in slide fatalities by region, 1980 to 2006**

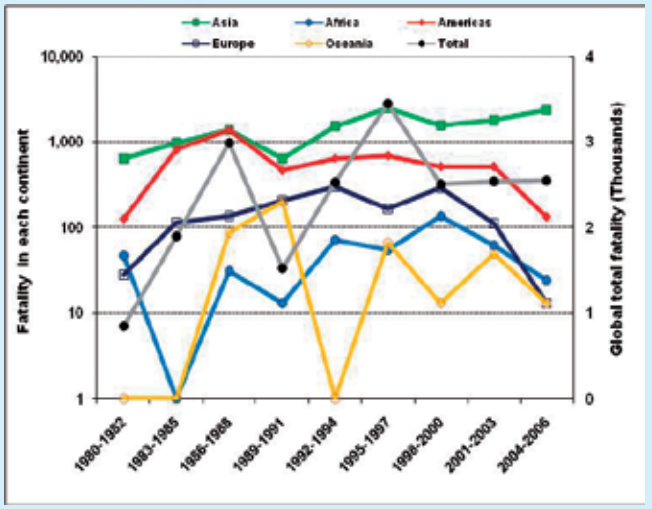


Figure 3.15 **Recorded wave and surge fatalities by region, 1980 to 2006**

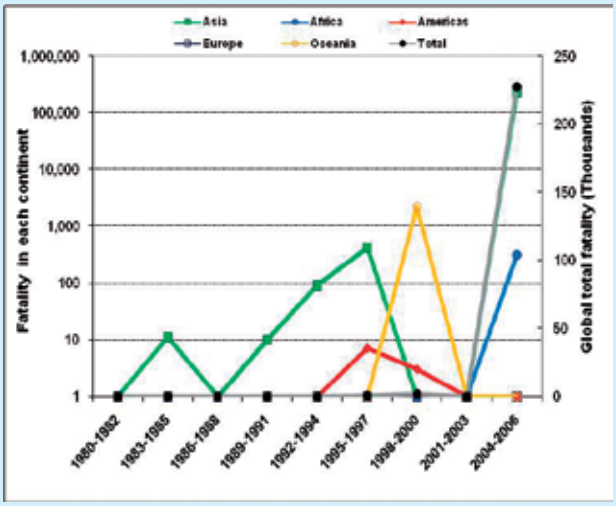


Figure 3.16 **Recorded drought fatalities by region, 1980 to 2006**

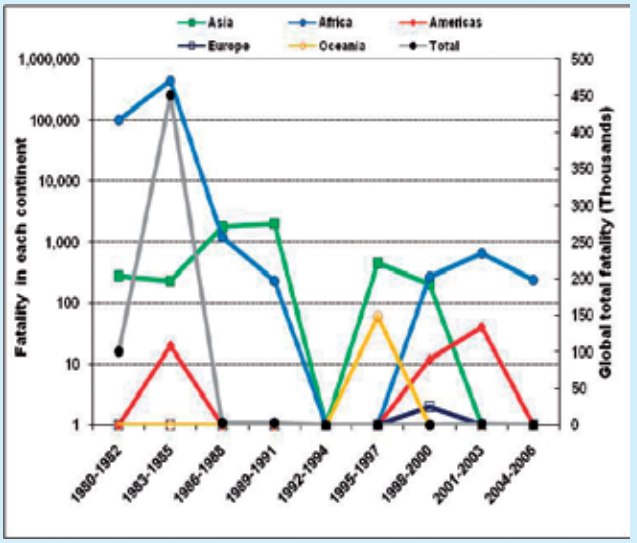


Figure 3.17 **Trends in fatalities from water-borne epidemics by region, 1980 to 2006**

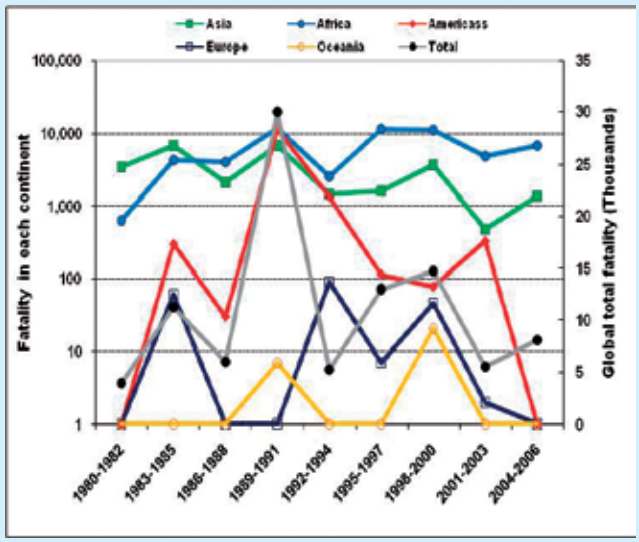


Table 3.2 **The reported number of people affected by different types of water-related disaster, with total and percent ratios and regional totals, between 1986 and 2006**

Continent	Flood (%)	Wind storm (%)	Slide (%)	Wave and surge (%)	Drought (%)	Epidemics (%)	Continent total (%)
Asia	2506206497 (96.7)	595190464 (90.4)	6098090 (89.3)	2406715 (95.1)	1220524542 (80.6)	621740 (45.6)	**4331048048 (90.7)**
Africa	35996167 (1.4)	9690871 (1.5)	20304 (0.3)	109913 (4.3)	232286096 (15.3)	628637 (46.1)	**278731988 (5.8)**
America	41238333 (1.6)	39388675 (6.0)	653385 (9.6)	3572 (0.1)	43161120 (2.9)	103205 (7.6)	**124548290 (2.6)**
Europe	8177955 (0.3)	8121212 (1.2)	42521 (0.6)	0 (0.0)	10272575 (0.7)	5607 (0.4)	**26619870 (0.6)**
Oceania	530301 (0.0)	5642064 (0.9)	10415 (0.1)	9867 (0.4)	8027635 (0.5)	3572 (0.3)	**14223854 (0.3)**
Total affected per disaster type	**2592149253 (54.3)**	**658033286 (13.8)**	**6824715 (0.1)**	**2530067 (0.1)**	**1514271968 (31.7)**	**1362761 (0.0)**	**4775172050 (100)**

Windstorms

Between 1980 and 2006, windstorm fatalities did not follow any trend but there are two important crests; one in Asia between 1989 and 1991, recording fatalities in six-digit figures, and the other in the Americas during the period from 1998 to 2000, recording five-digit numbers of fatalities (Figure 3.13). Europe, Africa and Oceania did not have significant fluctuations. The global total of fatalities from windstorms showed a very sharp crest during the Asian peak and another smaller crest during the Americas' peak years. This means that these two regions are the most vulnerable to windstorms. More than 138,000 lives were claimed by the Bangladesh cyclone in 1991, which coincides with the Asian and global peaks. Asia alone accounts for more than 64% of the windstorm fatalities followed by the Americas with more than 13% from 1980 to 2006 (Table 3.1).

Slides

The number of fatalities caused by slides increased in Asia between 1980 and 2006, with a peak in the period 1995 to 1997 (Figure 3.14). Fatalities in the Americas steadily decreased from 1988, though there was a sharp increase at the beginning of the 1980s. In Europe, fatalities caused by slides increased at the beginning of the 1980s, remained steady until the late 1990s, and then decreased. The total number of fatalities caused by slides globally shows two crests: one in the late 1980s and another in the late 1990s. More than 64% of the fatalities between 1980 and 2006 occurred in Asia, 25% occurred in the Americas, and 6.5% occurred in Europe (Table 3.1).

In February 2006, the monstrous St. Bernard Landslide in Leyte in the Philippines killed more than 1,200 people. In 1986 and 1987, more than 800 people were killed by slides in Colombia, and there were more than 600 fatalities in India and Nepal in 1988 – underlining the fact that Asia and the Americas are the most slide-prone regions of the world.

Waves and surges (including tsunami)

Waves and surges in Asia are increasing and the phenomenon is recorded sporadically in other regions such as the Americas, Africa and Oceania, which means that they are increasing in general (Figure 3.15). Information about waves and surges is scarce, but the vivid memory of the tragedy brought about by the colossal Indian Ocean tsunami in 2004, which claimed the lives of nearly 243,000 people, will never be forgotten. Approximately 99% of the total fatalities worldwide between 1980 and 2006 were Asians, which further suggests that the region is the most vulnerable to wave and surge disasters (Table 3.1).

Droughts

Drought fatalities in Africa between 1980 and 2006 increased until 1985, decreased until 1997, then started to increase again (Figure 3.16). In Asia, drought fatalities increased until 1991 and then declined suddenly. In general, drought fatalities were recorded more commonly around the world indicating an increase in severity.

During the period from 1980 to 2006, more than 99% of the total drought fatalities globally were reported in Africa (Table 3.1). For example, the fatalities in Sudan and Ethiopia in 1983 added up to 450,000. Drought fatalities were the highest during the period from 1983 to 1985 when droughts occurred in Africa.

Epidemics (water-related)

In general, fatalities caused by water-borne epidemics decreased in Asia but remained steady in Africa between 1980 and 2006 (Figure 3.17). Fatalities from water-borne epidemics were at their highest during the period from 1989 to 1991, when diarrhoea in Peru and cholera in Nigeria caused about 17,000 deaths. During the period from 1980 to 2006, about 58% of the total fatalities globally were recorded in Africa and 28% in Asia, though the numbers of water-related disasters were higher in Asia than in Africa (Table 3.1). The Americas ranked third-worst in water-borne epidemic fatalities during the same period, with slightly more than 14%.

Overall, fatalities caused by water-borne epidemics were highest in the 1990s, when Africa, Asia and the Americas were all hit hard by epidemics. Since then, the levels of fatalities have declined in all three regions.

Figure 3.18 **Recorded number of people affected by floods, 1980 to 2006**

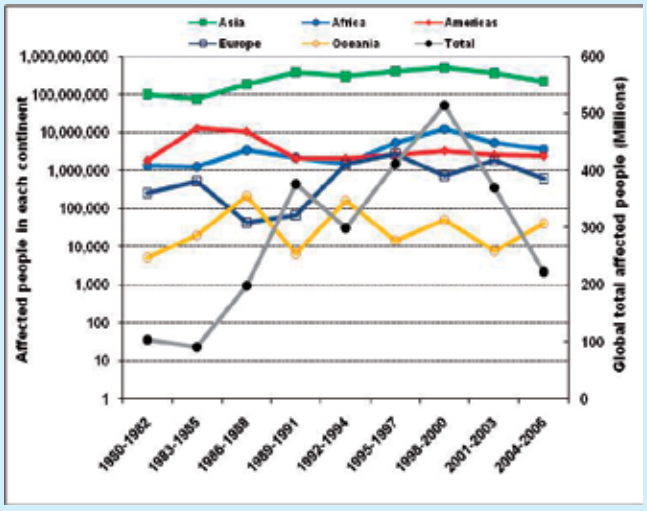


Figure 3.19 **Recorded number of people affected by windstorms, 1980 to 2006**

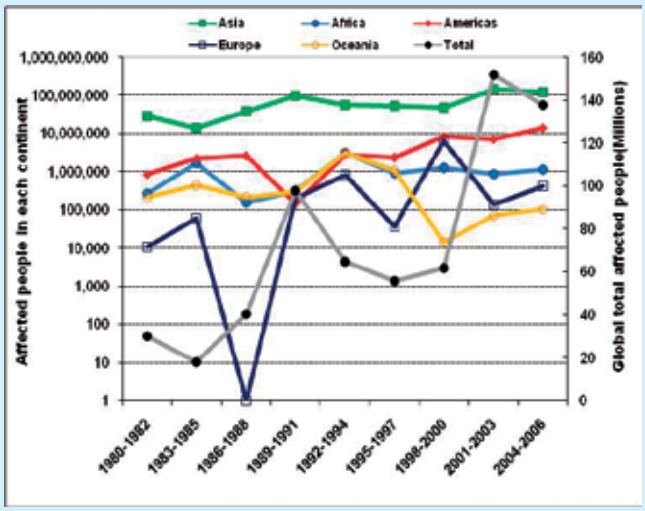


Figure 3.20 **Recorded number of people affected by slides, 1980 to 2006**

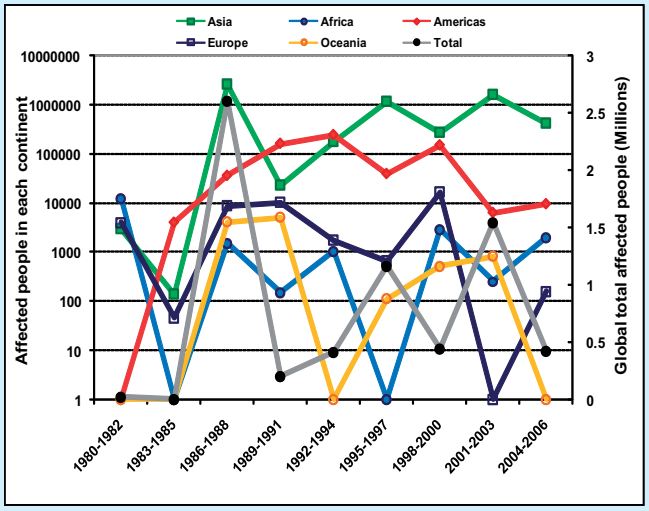


Figure 3.21 **Recorded number of people affected by waves and surges (including tsunami), by region, 1980 to 2006**

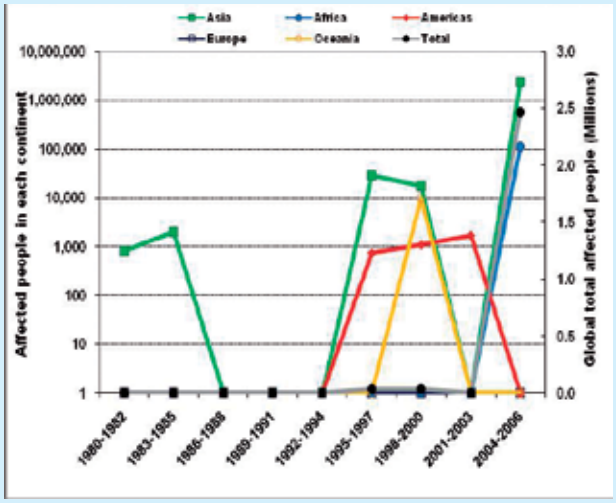


Figure 3.22 **Recorded number of people affected by droughts, by region, 1980 to 2006**

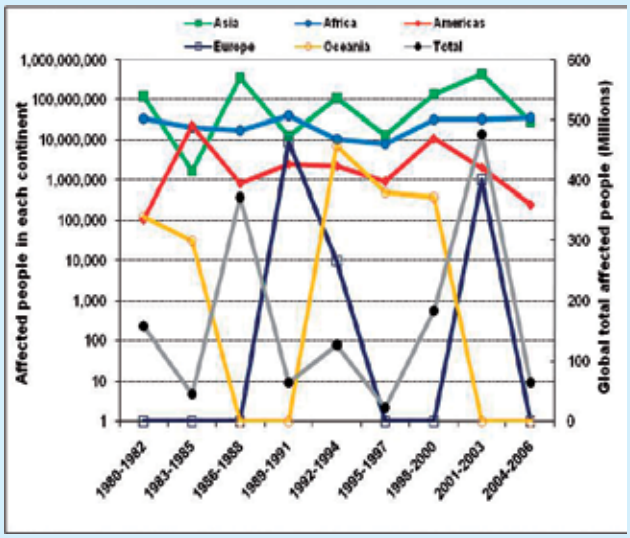
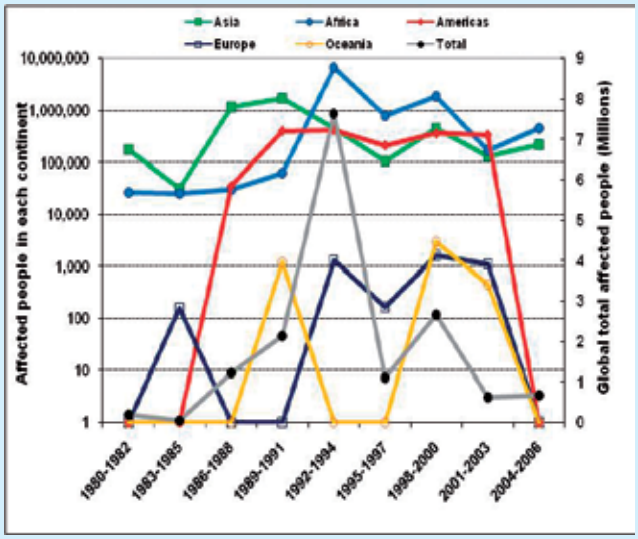


Figure 3.23 **Recorded number of people affected by water-borne epidemics, by region, 1980 to 2006**



Regional trends in the number of people affected by water-related disasters

Floods

Records show that Asia had the highest number of people affected by floods during the period from 1980 to 2006, with a steady nine-digit number. Until the mid 1990s, the Americas had the second-highest number, but Africa has since overtaken the Americas (Figure 3.24). There was no major fluctuation in the numbers between 1980 and 2006 except that Asia had a crest during the period from 1998 to 2000. There were close to 100 million people affected in 1999 and more than 58% of that number was affected by the 1998 flood in China. Asia is the most flood-prone region in the world in terms of the number of people affected. Almost 97% of the total number of people affected by floods between 1980 and 2006 were in Asia alone. (Table 3.2).

Windstorms

From 1980 to 2006, the number of people affected by windstorms increased significantly in all the regions except in Oceania. The global total rose from just over 30 million to more than 137 million – which is more than a four-fold increase. (Figure 3.19). A notable increase was recorded in Asia, which went from an eight-digit number of fatalities to a nine-digit number. Fatalities in the Americas rose from a six-digit to an eight-digit number, and fatalities in Europe went from five-digit to six-digit figures. More than 90% of all people affected by windstorms were recorded in Asia, followed by the Americas with about six percent, and by Africa, Europe and Oceania in that order (Table 3.2). The total number of people affected by windstorms increased drastically between 2000 and 2006.

Slides

The number people reported to be affected by slides increased sharply in Asia and the Americas during the period from 1980 to 2006 (Figure 3.20). The highest number recorded was during the late 1980s, reflecting the major casualties caused by the 1986 landslides in India. The number of people affected by slides did not show any particular trend in Europe, Africa and Oceania. More than 89% of those affected by slides between 1980 and 2006 lived in Asia (Table 3.2), 9% lived in the America, and Europe was the region with the next-highest number.

Waves and surges (including tsunami)

Tsunami cause major wave and surge disasters. The reported number of people affected by waves and surges from 1980 to 2006 did not follow any particular trend in any region (Figure 3.21). Only in Asia were there any statistics for people affected by waves and surges for the period from 1980 to the mid 1990s. But the number of people affected started to increase in the mid 1990s and victims were recorded in the Americas, Africa and Oceania but not in Europe. A total of 2.5 million people affected by tsunami has been recorded since 1980; 95% of those affected live in Asia and a little more than four per cent in Africa (Table 3.2). Most of those affected were the victims of the Indian Ocean tsunami in 2004.

Droughts

Records show that there was no general trend in the number of people affected by droughts in any of the regions, but there were individual crests and troughs in each region, such as the 1986–1988 and 2001–2003 crests in Asia, the 1989–1991 crest in Africa, the 1989–1991 and 2001–2003 crests in Europe, and a prolonged drought from 1989 to 2000 in Oceania (Figure 3.22). More people were affected by droughts than any other water-related disaster during the period from 1980 to 2006. Asians suffered most with more than 80% of the global total of affected people (Table 3.2). In India alone, as many as 300 million people were affected by droughts in 1987 and 2002, which were historical extremes worldwide until today. Africa and the Americas were the second- and third-worst hit. In recent years, Australia (1.75 million drought-affected people in the 1990s), Spain and other countries in different regions have been suffering from droughts, and almost 50% of the ten worst famines have been triggered by droughts.

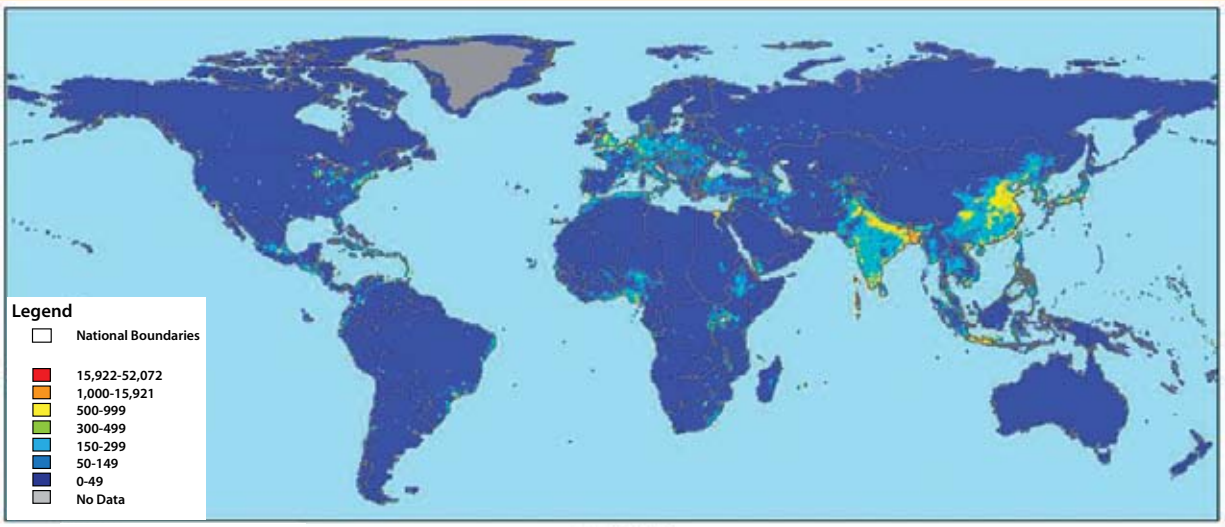
Epidemics (water-borne)

A general trend shows that the number of people affected by epidemics peaked in the mid-1990s and then declined. In Africa, the number of people reported to be affected by water-borne epidemics increased, with a crest between 1992 and 1994. Asia's casualty numbers peaked in the period from 1989 to 1991 and then decreased. However, water-borne epidemics affecting people in the Americas increased drastically during the period from 1986 to 2003, and in Europe during the period 1992 to 2003 (Figure 3.23). Nearly 60% of the total numbers affected by water-borne epidemics globally were from Africa, which had a drastic increase between 1992 and 1994. The 1994 malaria in Kenya affected over six million people and the 1991 diarrheal/enteric epidemics in Bangladesh affected another one-and-a-half million people. The situation is worsening since epidemics have started to emerge in Oceania and Europe.

Temporal change of risk factors

Even under current geographical, meteorological and socio-economic conditions, the level of water-related disaster management is far from sufficient and many vulnerability factors are increasing as a result of globally observed changes such as urbanization and population growth in slums and marginalized areas. It is important to understand that it's not only disasters that are increasing but also the drivers that catalyse disasters, such as increases in population in disaster-prone areas. Asia is the most populated region where mega-cities with huge populations are located in disaster-prone areas with the worst recorded flood-related casualties (Figure 3.24). As mentioned earlier, between 1980 and 2006, more than 71% of natural disaster fatalities occurred in Asia, of which more than 83% were flood-related. More than 45% of the world's water-related disaster

Figure 3.24 **Global population density**



Source: ICHARM/PWRI, based on data from SEDAC, http://sedac.ciesin.columbia.edu/gpw

fatalities occurred in Asia, and the figure for Africa is similar at 46%. This clearly indicates that Asian and African regions should prioritize water-related disaster management schemes through the formulation of regional, sub-regional and national development policies.

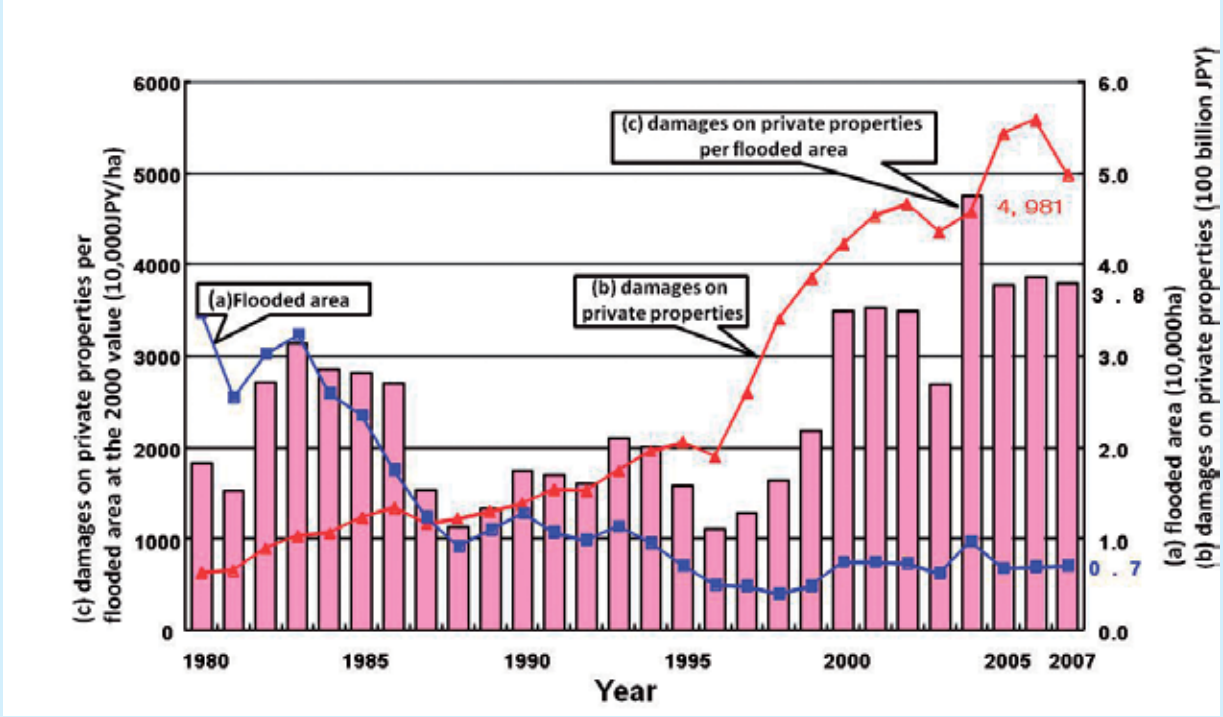
Carefully analysed disaster damage figures for individual countries can be a basis for establishing new policies. How important information can be for policy-making is clarified with a Japanese example (Figure 3.25). The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has released figures showing comparative trends of flooded areas and damage density on private property after the late 1970s. Figure 3.25 indicates a clear increase in flood damage density in inverse proportion to decreased flooded areas. The decline of flooded areas suggests the effectiveness of past flood control projects and the increase in the damage density suggests the continued concentration and increase of private property in flood-prone areas. Such data can be a basis to start a discussion on the necessity of an integrated risk-management approach beyond the present administrative scheme. New policy-making could be much more convincing if data, such as past investment in flood control projects or damage by unplanned land use, were available at global, national and regional levels.

As shown in Figure 3.26 the number of water-related disaster fatalities in Bangladesh decreased drastically within four decades even though powerful high-category cyclones continued to hit the nation. The most remarkable thing to note is that the number of fatalities caused by similar-magnitude cyclones decreased from more than 300,000 in 1970 to just over 5,000 in 2007. This difference is the result of continuous hard and soft mitigation efforts such as implementing the Cyclone Preparedness Programme, planting mangrove, constructing cyclone shelters, and introducing warning systems. All these fruitful measures have been brought in by the Bangladeshi government and by efforts of the international community to secure the country from disaster.

However, the number of fatalities and the number of people affected depends very much on individual disaster event extremities, the location of the disaster, and social and demographic circumstances; it can be difficult to find a reliable trend that shows a particular way forward. Trends may depend on population densities, economic migration to exposed areas, and the occurrence time and magnitude of a disaster – for instance, a tsunami might cause hundreds of fatalities in an unexpected location, or a glacier lake outburst flood somewhere in the Himalayas might flood Bangladesh and leave many people dead.

Furthermore, the huge number of people affected by disasters in Asia and the high number of fatalities in Africa caused by water-related disasters call for immediate action by national and international communities. Therefore, all stakeholders are urged to factor disaster-risk considerations into development policy at the national level, to invest directly in disaster management, and to create transparent and reliable national and international databases for smooth policy-making processes, as well as improving disaster relief to save lives and property and working towards achieving development goals.

Figure 3.25 **Flood damages in Japan from 1980 to 2007**



Though the flooded area is decreasing, the cost of the damage to property is increasing. 1) Five year average plotted, 2) Damage includes business suspension loss and 3) Damages are deflated to the 2000 value

Conclusions and recommendations

Conclusions

The following are some of the conclusions derived from the global water-related disaster trends:

Globally, the number of natural disasters that occur and the cost of the damage they cause are increasing. The recorded number of natural disaster events in the year 1900 was only six, but by 2006 the number had increased to 409 and is expected to increase further. The average number of events jumped abruptly in the late 1990s compared with the beginning of the decade. The number of disaster events recorded around the world between 1900 and 2007 was 16,301 and the number of people affected was 6.27 billion, with more than 37.58 million fatalities. The estimated financial loss caused by natural disasters in the 1970s was US$75.5 billion, whereas the estimated loss during the period from 2000 to 2008 was US$702.3 billion.

Among the world's one thousand most fatal natural disasters between 1900 and 2006, floods, windstorms and droughts accounted for up to 88.5 per cent. This means that water-related disasters are the most frequent natural disasters.

The number of natural-disaster fatalities globally has dropped significantly in the recent past, despite an increase in world population. This might be attributable to continuous efforts made by various governments, organizations and agencies around the world that are involved in disaster management. Continued efforts against increasing numbers of natural disasters are indispensable.

Asia is prone to floods, windstorms and slides, among other water-related disasters, and Africa is particularly prone to water-borne epidemics. The ranking according to the number of water-related disasters they experience is Asia, Africa, the Americas, Europe and Oceania, in descending order.

The regional distribution shows that Asia is the region most prone to water-related casualties, accounting for more than 45% of the world's water-related disaster fatalities during the period from 1980 to 2006, and 90% of all by water-related casualties. Africa comes next, accounting for more than 46 percent of all water-related disaster fatalities, and is followed by the Americas, Europe and Oceania, in descending order. Between 1980 and 2006; more than 71% of the world's natural-disaster fatalities occurred in Asia, of which more than 83% were flood-related.

Recommendations

The aim of this report is to provide an insight for policymakers, practitioners, scientists, and international and local communities on the status of the trends of past water-related disasters; and to highlight their impacts on citizens around the world,

thus making them aware of water-related disaster vulnerability. These trends in disasters also affect the way disaster risk and vulnerability are examined and perceived. This report uniquely points out that water-related disasters are increasing every year, causing enormous damage to life and property, some of which could have been protected through appropriate development choices. Furthermore, future development gains are just as much at stake. Therefore, it is recommended that policy-making should be built on the following facts:

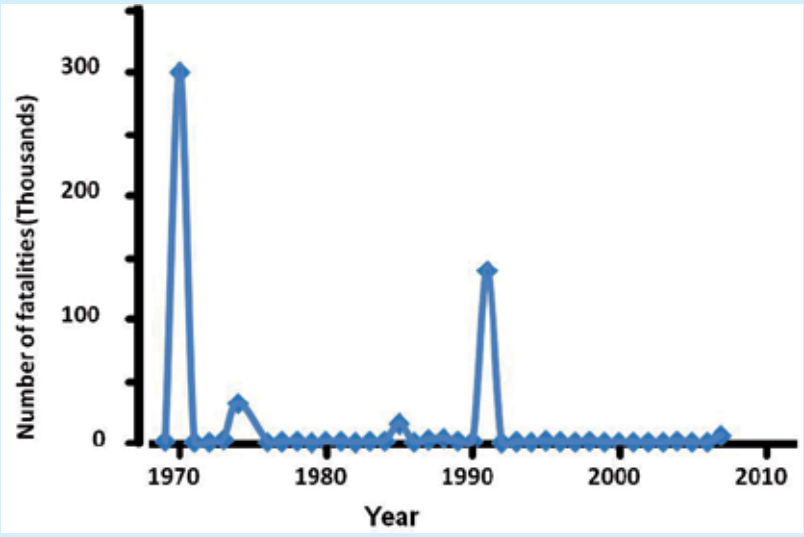
1. Water-related disasters should be a national planning priority given that their frequency and magnitude is increasing.
2. It is important to have knowledge of the trends of water-related disasters, particularly which disaster trends are changing, in what way, and how this could be projected into the future. Such knowledge is important for factoring disaster risk consideration into development policy at the national level in order to plan, manage and mitigate disasters.
3. Water-related disaster fatalities are decreasing, but the estimated economic loss as an aftermath of these disasters is increasing; therefore, basin management plans should be executed, rather than city or town plans, on the basis of an increased understanding of disaster trends and foresightedness.
4. Governments should keep in mind that water-related disaster management is a primary step towards reducing water-borne epidemics. Africa should act fast to reduce the number of fatalities from epidemics, whereas Asia and the Americas should work hard to mitigate floods, windstorms and slides.
5. The gaps in our knowledge about water-related disaster management should be reduced to foster resilient communities, especially in developing countries.
6. EM-DAT is a reliable data source, but additional accurate and reliable databases are necessary in the international community for policy development. Without reliable data sources, results may not be appropriate for sound policy-making. Furthermore, detailed data and its comprehensive analysis are indispensable for good policy development.
7. Water-related disaster management is important in order to protect lives and property and to encourage willingness in those with greater resources to assist those with fewer.

'Modern society has distinct advantages over those civilizations of the past that suffered or even collapsed for reasons linked to water. We have great knowledge, and the capacity to disperse that knowledge to the remotest places on earth. We are also beneficiaries of scientific leaps that have improved weather forecasting, agricultural practices, natural resources management, disaster prevention, preparedness and management . . . But only a rational and informed political, social and cultural response – and public participation in all stages of the disaster management cycle – can reduce disaster vulnerability, and ensure that hazards do not turn into unmanageable disasters.'

Kofi Annan

Message on World Water Day 2004

Figure 3.26 **Water-related disaster fatalities in Bangladesh, 1970 to 2007**



Note that although similar category cyclones occurred in 1970, 1991 and 2007, the number of fatalities decreased drastically.

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Appendix

EM-DAT water-related disaster glossary

Definitions are from the International agreed glossary of basic terms related to Disaster Management (1992) UN-DHA, IDNDR, Geneva. For a glossary of non-water-related terms, visit the EM-DAT web page at http://www.EMDAT.be.

Avalanche:
Rapid and sudden sliding and flowage of masses of usually unsorted mixtures of snow/ice/rock material.

Collapse:
Accident involving the collapse of building or structure. Can either involve industrial structures

Crop failure:
Abnormal reductions in crop yield such that it is insufficient to meet the nutritional or economic needs of the community.

Cyclone:
Large-scale closed circulation system in the atmosphere above the Indian Ocean and South Pacific with low barometric pressure and strong winds that rotate clockwise. Maximum wind speed of 64 knots or more (See 'hurricane' for the western Atlantic and eastern Pacific and 'typhoon' for the western Pacific).

Drought:
Period of deficiency of moisture in the soil such that there is inadequate water required for plants, animals and human beings.

Epidemic:
Either an unusual increase in the number of cases of an infectious disease, which already exists in the region or population concerned; or the appearance of an infection previously absent from a region.

Famine:
Catastrophic food shortage affecting large numbers of people due to climatic, environmental and socio-economic reasons.

Flood:
Significant rise of water level in a stream, lake, reservoir or coastal region.

Food shortage:
Lack of alimentation bases.

Hazard:
Threatening event, or probability of occurrence of a potentially damaging phenomenon within a given time period and area.

Hurricane:
disaster subset of disaster type 'windstorm'. Large-scale closed-circulation system in the atmosphere above the western Atlantic, with low barometric pressure and strong winds that rotate clockwise in the southern hemisphere and counter-clockwise in the northern hemisphere. Maximum wind speed of 64 knots or more (See 'cyclone' for the Indian Ocean and South Pacific and Eastern Pacific and 'typhoon' for the Western Pacific).

Landslide:
In general, all varieties of slope movement, under the influence of gravity. More strictly refers to down-slope movement of rock and/or earth masses along one or several slide surfaces.

Slide:
Disaster type term used in EM-DAT comprising the two disaster subsets 'avalanche' and 'landslide'.

Storm:
Wind with a speed between 48 and 55 knots.

Tidal wave:
Abrupt rise of tidal water (caused by atmospheric activities) moving rapidly inland from the mouth of an estuary or from the coast.

Tornado:
Violently rotating storm diameter; the most violent weather phenomenon. It is produced in a very severe thunderstorm and appears as a funnel cloud extending from the base of a cumulonimbus to the ground.

Tropical storm:
Generic term for a non-frontal synoptic scale cyclone originating over tropical or sub-tropical waters with organised convection and definite cyclonic surface wind circulation.

Tsunami:
Series of large waves generated by sudden displacement of seawater (caused by earthquake, volcanic eruption or submarine landslide); capable of propagation over large distances and causing a destructive surge on reaching land. The Japanese term for this phenomenon, which is observed mainly in the Pacific, has been adopted for general usage.

Typhoon:
Large-scale closed circulation system in the atmosphere above the western Pacific with low barometric pressure and strong winds that rotate clockwise in the southern hemisphere and counter-clockwise in the northern hemisphere. Maximum wind speed of 64 knots or more.

Wave/surge:
Disaster type term used in EM-DAT comprising the two disaster subsets 'tsunami' and 'tidal wave.'

Windstorm:
Disaster type term comprises the following disaster

subsets cyclone, hurricane, storm, tornado, tropical storm, typhoon, winter storm.

Winter storm:
Snow (blizzard), ice or sleet storm.

Important UN/ISDR definitions

Capacity:
A combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster. Capacity may include physical, institutional, social or economic means as well as skilled personal or collective attributes such as leadership and management. Capacity may also be described as capability.

Capacity building:
Efforts aimed to develop human skills or societal infrastructures within a community or organization needed to reduce the level of risk. In extended understanding, capacity building also includes development of institutional, financial, political and other resources, such as technology at different levels and sectors of the society.

Climate change:
The climate of a place or region is changed if over an extended period (typically decades or longer) there is a statistically significant change in measurements of either the mean state or variability of the climate for that place or region.

Coping capacity:
The means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and human-induced hazards.

Counter measures:
All measures taken to counter and reduce disaster risk. They most commonly refer to engineering (structural) measures but can also include non-structural measures and tools designed and employed to avoid or limit the adverse impact of natural hazards and related environmental and technological disasters.

Disaster:
A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk.

Disaster risk management:
The systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.

Disaster risk reduction (disaster reduction):
The conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development. The disaster risk reduction framework is composed of the following fields of action, as described in ISDR's 2002 publication *Living with Risk: A Global Review of Disaster Reduction Initiatives* (p. 23):

- Risk awareness and assessment: includes hazard analysis and vulnerability/capacity analysis.
- Knowledge development including education, training, research and information.
- Public commitment and institutional frameworks, including organisational, policy, legislation and community action.
- The application of measures including environmental management, land-use and urban planning, protection of critical facilities, the application of science and technology, partnership and networking, and financial instruments.
- Early warning systems including forecasting, dissemination of warnings, preparedness measures and reaction capacities.

Early warning:
The provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response. Early warning systems include a chain of concerns, namely: understanding and mapping the hazard; monitoring and forecasting impending events; processing and disseminating understandable warnings to political authorities and the population, and undertaking appropriate and timely actions in response to the warnings.

Emergency management:
The organization and management of resources and responsibilities for dealing with all aspects of emergencies, in particular preparedness, response and rehabilitation. Emergency management involves plans, structures and arrangements established to engage the normal endeavours of government and voluntary and private agencies in a comprehensive and co-ordinated way to respond to the whole spectrum of emergency needs. This is also known as disaster management.

Forecast:
Definite statement or statistical estimate of the occurrence of a future event. This term is used with different meanings in different disciplines.

Geological hazard:
Natural earth processes or phenomena that may cause loss of life or injury, property damage, social and economic disruption, or environmental degradation. Geological hazards include internal earth processes of tectonic origin, such as earthquakes, geological fault activity, tsunamis, volcanic activity and emissions, as well as external processes such as mass movements: landslides, rock slides, rock falls or avalanches, surface collapses, expansive soils and debris or mud flows. Geological hazards can be single, sequential or combined in their origin and effects.

Geographic information systems (GIS):
An analysis that combines relational databases with spatial interpretation and outputs often in the form of maps. A more elaborate definition is computer programmes for capturing, storing, checking, integrating, analysing and displaying data about the earth that is spatially referenced. Geographical information systems are increasingly being utilised for hazard and vulnerability mapping and analysis, as well as for the application of disaster risk management measures.

Hazard:
A potentially damaging physical event, phenomenon or human activity that may cause loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological or biological) or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterised by its location, intensity, frequency and probability.

Hazard analysis:
Identification, studies and monitoring of any hazard to determine its potential, origin, characteristics and behaviour.

Hydrometeorological hazards:
Natural processes or phenomena of atmospheric, hydrological or oceanographic nature, which may cause loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hydrometeorological hazards include: floods, debris and mud floods; tropical cyclones, storm surges, thunder/hailstorms, rain and windstorms, blizzards and other severe storms; drought, desertification, wildland fires, temperature extremes, sand or dust storms; permafrost and snow or ice avalanches. Hydrometeorological hazards can be single, sequential or combined in their origin and effects.

Land-use planning:
Branch of physical and socio-economic planning that determines the means and assesses the values or limitations of various options in which land is to be utilized, with the corresponding effects on different segments of the population or interests of a community taken into account in resulting decisions. Land-use planning involves studies and mapping, analysis of environmental and hazard data, formulation of alternative land-use decisions and design of a long-range plan for different geographical and administrative scales.

Land-use planning can help to mitigate disasters and reduce risks by discouraging high-density settlements and construction of key installations in hazard-prone areas, control of population density and expansion, and in the siting of service routes for transport, power, water, sewage and other critical facilities.

Mitigation:
Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

Natural hazard:
Natural processes or phenomena occurring in the biosphere that may constitute a damaging event. Natural hazards can be classified by origin namely: geological, hydrometeorological or biological. Hazardous events can vary in magnitude or intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing.

Preparedness:
Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.

Prevention:
Activities to provide outright avoidance of the adverse impact of hazards and means to minimize related environmental, technological and biological disasters. Depending on social and technical feasibility and cost/benefit considerations, investing in preventive measures is justified in areas frequently affected by disasters. In the context of public awareness and education, related to disaster risk reduction changing attitudes and behaviour contribute to promoting a 'culture of prevention'.

Public awareness:
The processes of informing the general population and increasing levels of consciousness about risks and how people can act to reduce their exposure to hazards. This is particularly important for public officials in fulfilling their responsibilities to save lives and property in the event of a disaster. Public awareness activities foster changes in behaviour leading towards a culture of risk reduction. This involves public information, dissemination, education, radio or television broadcasts, use of

printed media, as well as the establishment of information centres and networks and community and participation actions.

Public information:
Information, facts and knowledge provided or learned as a result of research or study, available to be disseminated to the public.

Resilience/resilient:
The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

Risk:
The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Conventionally risk is expressed by the notation Risk = Hazards x Vulnerability. Some disciplines also include the concept of exposure to refer particularly to the physical aspects of vulnerability. Beyond expressing a possibility of physical harm, it is crucial to recognize that risks are inherent or can be created or exist within social systems. It is important to consider the social contexts in which risks occur and that people therefore do not necessarily share the same perceptions of risk and their underlying causes.

Risk assessment/analysis:
A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend.

The process of conducting a risk assessment is based on a review of both the technical features of hazards such as their location, intensity, frequency and probability; and also the analysis of the physical, social, economic and environmental dimensions of vulnerability and exposure, while taking particular account of the coping capabilities pertinent to the risk scenarios.

Structural/non-structural measures:
Structural measures refer to any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure. Non-structural measures refer to policies, awareness, knowledge development, public commitment, and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce risk and related impacts.

Sustainable development:
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of 'needs', – in particular the essential needs of the world's poor, to which overriding priority should be given – and the idea of limitations, imposed by the state of technology and social organization, on the environment's ability to meet present and the future needs (Brundtland Commission, 1987). Sustainable development is based on socio-cultural development, political stability, economic growth, and ecosystem protection, which all relate to disaster risk reduction.

Vulnerability:
The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards. For positive factors, which increase the ability of people to cope with hazards, see 'capacity'.

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World Water Assessment Programme side publications, March 2009

During the consultation process for the third edition of the World Water Development Report, a general consensus emerged as to the need to make the forthcoming report more concise, while highlighting major future challenges associated with water availability in terms of quantity and quality.

This series of side publications has been developed to ensure that all issues and debates that might not benefit from sufficient coverage within the report would find space for publication.

The 17 side publications released on the occasion of the World Water Forum in Istanbul in March, 2009, in conjunction with *World Water Development Report 3: Water in a Changing World*, represent the first of what will become an ongoing series of scientific papers, insight reports and dialogue papers that will continue to provide more in-depth or focused information on water–related topics and issues.

Insights

IWRM Implementation in Basins, Sub-Basins and Aquifers: State of the Art Review
by Keith Kennedy, Slobodan Simonovic, Alberto Tejada-Guibert, Miguel de França Doria and José Luis Martin for UNESCO-IHP

Institutional Capacity Development in Transboundary Water Management
by Ruth Vollmer, Reza Ardakanian, Matt Hare, Jan Leentvaar, Charlotte van der Schaaf and Lars Wirkus for UNW-DPC

Global Trends in Water-Related Disasters: An Insight for Policymakers
by Yoganath Adikari and Junichi Yoshitani at the Public Works Research Institute, Tsukuba, Japan, for the International Center for Water Hazard and Risk Management (ICHARM), under the auspices of UNESCO.

Inland Waterborne Transport: Connecting Countries
by Sobhanlal Bonnerjee, Anne Cann,Harald Koethe, David Lammie, Geerinck Lieven, Jasna Muskatirovic, Benjamin Ndala, Gernot Pauli and Ian White for PIANC/ICIWaRM

Building a 2nd Generation of New World Water Scenarios
by Joseph Alcamo and Gilberto Gallopin

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Updating the International Water Events Database
by Lucia De Stefano, Lynette de Silva, Paris Edwards and Aaron T. Wolf, Program for Water Conflict Management and Transformation, Oregon State University, for UNESCO PCCP

Water Security and Ecosystems: The Critical Connection
by Thomas Chiramba and Tim Kasten for UNEP

Scientific Papers

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by Jon Martin Trondalen for UNESCO PCCP

A Multi-Model Experiment to Assess and Cope with Climate Change Impacts on the Châteauguay Watershed in Southern Quebec
by Luc Vescovi, Ouranos; Ralf Ludwig, Department of Geography, University of Munich; Jean-François Cyr, Richard Turcotte and Louis-Guillaume Fortin, Centre d'Expertise Hydrique du Québec; Diane Chaumont, Ouranos; Marco Braun and Wolfram Mauser, Department of Geography, University of Munich

Water and Climate Change in Quebec
by Luc Vescovi, Ouranos; Pierre Baril, Ministry of Transport, Québec; Claude Desjarlais ; André Musy; and René Roy, Hydro-Québec. All authors are members of the Ouranos Consortium

Investing in Information, Knowledge and Monitoring
by Jim Winpenny for the WWAP Secretariat

Water Footprint Analysis (Hydrologic and Economic) of the Guadania River Basin
by Maite Martinez Aldaya, Twente Water Centre, University of Twente and Manuel Ramon Llamas, Department of Geodynamics, Complutense University of Madrid, Spain

The International Center for Water Hazard and Risk Management (ICHARM) operates under the auspices of UNESCO and was established within the Public Works Research Institute (PWRI), Tsukuba, Japan in March 2006. ICHARM's objective is to serve as a global Center of Excellence to provide and help implement the best practicable strategies to manage the risk of water-related disasters.

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